

rently abnormal disturbances, was very nearly 4^s , while that of Westminster, taken in the same way for 1872, was only 1^s . The Exchange rate was materially improved afterwards, by the substitution of a better remontoire, but I have no later record of it, and the clock passed into other hands in 1860; old Mr. Dent's foreman, who had the making and the care of it till then, and has since had that of Westminster, has often told me that it never approached Westminster in steadiness of rate. The average weekly variation of one of his best "regulators" for the same period as the Exchange clock was 2^s ; and the rate of his 1851 Exhibition great clock, with pin-wheel dead escapement and the best train remontoire, was reported as being quite equal to that of the regulator fixed beside it. So that we may probably consider the rate of a rightly made large gravity escapement clock twice as good as that of any dead escapement one, large or small, and its barometric error much less, if not altogether neutralised.

On the Re-discovery of Biela's Comet. By M. Klinkerfues.

On comparing the brilliant meteoric shower of November 27th with those of other years, more especially with that of 1805, in which year, to the best of my knowledge, nothing of a similar character was observed, although the circumstances were particularly favourable, I was led to the assumption that in this instance we were in the closest proximity to Biela's Comet. A simple geometric consideration suffices to show that under these circumstances the comet must remain almost stationary in the neighbourhood of the radiant of convergence for a few days immediately following the occurrence of the meteoric shower, and further that there was even a hope of finding the comet itself, provided the intelligence could be at once transmitted to an observatory sufficiently far south. The paths of 80 meteors laid down by our Castellan, Mr. Heidorn, enabled me to determine the radiant point of divergence (R.A. = 26° ; Dec. = $+37^\circ$) without bias.

On November 30th I sent the following telegram to Madras: "Biela touched Earth November 27th; search near *Theta Centauri*." This telegram reached Madras by way of Russia in one hour and thirty-five minutes.

Concerning the result Mr. Pogson, under date December 6th, writes to me as follows:

"Nov. 30th, 16^h, the time of comet rising here, I was at my post but hopelessly; clouds and rain gave me no chance. The next morning I had the same bad luck. But on a third trial, a brief blue break about 17 $\frac{1}{4}$ ^h M.T., I found Biela immediately! Only four comparisons in successive minutes could be obtained, in strong morning twilight with an anonymous star; but direct motion of 2.5 seconds of time decided that I had got the comet all right. I noted it: 'Circular, bright, with a decided nucleus but no

tail, and about 45" in diameter.' Next morning I got seven good comparisons with an anonymous star, showing a motion of 17^s.9* in twenty-eight minutes, and I also got two comparisons with a Madras star in our current catalogue, and with 7734 Taylor. My notes were: 'Circular, diameter 75", bright nucleus, a faint but distinct tail, about 8' in length and position angle estimated 280° from the comet.' I was too anxious to secure one good place of the one in hand to look for the other comet, and the fourth morning was cloudy and rainy. I used power 99 on the equatoreal of Troughton and Simms, eight inches in aperture, but could see the comet well in the finder. At a guess I should describe it as three times as bright as the cluster 80 *Messier*, in the field with R., S., and T. *Scorpii*. The two positions, so far (the first only approximate, but the second pretty trustworthy I think ") are :—

Madras Mean Time.				App. R. A.			App. P. D.		
	^h	^m	^s	^h	^m	^s	[°]	[']	["]
Dec. 2	17	33	21	14	7	27	124	46	0
3	17	25	17	14	22	29	125	4	28

Professor Klinkerfues adds :—

"At present I am engaged in preparations for the calculation of an ephemeris, as I am not without hopes that a few positions may be obtained even after the lapse of a few weeks. Of course the first thing to be done on receipt of the above letter was to assure myself that no provoking accident had led to the discovery of a comet altogether unconnected with that of Biela, in the place indicated. A provisional determination of the points of intersection of Mr. Pogson's *directions of observation* (*Beobachtungsrichtungen*) with the old orbit of 1852 gave

Mean Greenwich Time.	Distance from the Earth.	Distance from the Sun.
Dec. 2 ^h 50 ^m 7 ^s 1	0 ^h 07 ^m 30 ^s 1	0 ^h 92 ^m 67 ^s 6
3 ^h 50 ^m 15 ^s	0 ^h 08 ^m 88 ^s 49	0 ^h 91 ^m 24 ^s 8

the heliocentric co-ordinates of the two places referred to the equator (mean equinox of 1872.0) are

α	δ	z
+ 0 ^h 26 ^m 67 ^s 2	+ 0 ^h 82 ^m 40 ^s 3	— 0 ^h 32 ^m 96 ^s 6
+ 0 ^h 24 ^m 22 ^s 4	+ 0 ^h 81 ^m 84 ^s 8	+ 0 ^h 32 ^m 25 ^s 6

The chord joining the two points of intersection is 0^h02^m61^s9, and finally the Earth's co-ordinates for Nov. 27^h33^m33^s are

$$X = + 0^{\text{h}}40^{\text{m}}85^{\text{s}}6; \quad Y = + 0^{\text{h}}82^{\text{m}}61^{\text{s}}5; \quad Z = + 0^{\text{h}}35^{\text{m}}84^{\text{s}}8;$$

and the Earth's radius-vector, $R. = 0^{\text{h}}98^{\text{m}}61^{\text{s}}8.$

* In Professor Klinkerfues's letter it is difficult to decide whether this is 17^s.9 or 17^m.9; the former reading agrees well with the observations.—*Trans.*

“An examination of the foregoing figures leaves scarcely a doubt as to the identity of the comet observed by Mr. Pogson with one of the two heads of Biela's comet, and at the same time they show that an unusually small minimal distance from the Earth occurred in the course of November 27th.”

Re-discovery of Biela's Comet. By Capt. Tupman.

Professor Klinkerfues was led to assign a place near θ Centauri as a natural consequence of his happy and bold idea that the comet itself had touched the Earth; and as it was found just as he expected, there was every reason to suppose that Pogson's two observations, combined with the supposed known position at the moment of contact, would give the real orbit.

I soon found that if the comet really grazed the Earth on the evening of Nov. 27th, it could not possibly have been observed in either of the positions given on December 2nd and 3rd, unless the inclination of the orbit be reduced to $7\frac{1}{2}^\circ$ (Query, $9\frac{1}{2}$.—ED.) The radiant point of the meteoric shower of Nov. 27th points infallibly to an inclination of $12\frac{1}{2}^\circ$.

It may be said that after passing so exceedingly near to the Earth, the direction of motion would probably be much affected, and a new orbit be imposed upon the comet; but if so, the two observations *after* that event would determine approximately the form of a new orbit. As a matter of fact, the two observations are utterly irreconcilable with one another, on any such hypothesis.

The discrepancies, however, disappear if we suppose,—

1. That the meteor shower was produced by an outlying portion of the Comet, far detached from either nucleus on the side farthest from the Sun, and moving nearly on the same radius vector prolonged.

2. That the *primary* comet overtook the Earth in longitude about Nov. 27th, $3-4^h$ at a distance from the Sun less than that of the Earth by 0.032 of the latter's mean distance, and was discovered by Mr. Pogson on December 3rd.

3. That the *secondary* comet overtook the Earth in a similar manner ten or twelve hours earlier, and was that seen by Mr. Pogson on December 2nd.

In any case the comets are some twelve weeks “behind their time.”*

* [It is easily shown that the meteor-flight traversed by the Earth on November 27 was far too scattered to be visible by reflected light. Moreover, a delay of Biela's Comet by twelve weeks could not be caused without a complete subversion of the orbit-element. It appears, however, that what Mr. Pogson saw was a meteoric aggregation travelling on the track of the comet; far behind, however; possibly double, as Capt. Tupman suggests; and certainly not coincident with the meteor-flight of November 27, which was probably on its outskirts.—R. A. P.]